4.0 TEST FINDINGS

This chapter summarizes the findings of the various field tests. Technical considerations related to camera selection and positioning are discussed, display preferences are outlined, and issues of accuracy are addressed.

4.1 EQUIPMENT CONSIDERATIONS

4.1.1 Illumination

Ambient Sunlight. The only lighting used during the enforcement tests was the ambient light from the sun. Thus every recording session presented a challenge, because the light intensity and angle of incidence was changing throughout the daytime hours. For instance, if the early-morning sun is directly behind the camera and the sunlight is directed downward into the front passenger compartment, then the passengers in the front seat will be well-illuminated and considerable detail can be recorded. However, late in the afternoon, the opposite condition will exist and the passengers will be seen in silhouette.

Clean, well-polished vehicles can also present a problem for the camera. As these vehicles move down the highway under the sun's rays, bright reflections can bounce off of the bumpers and chrome trim. On occasion, these reflections have been severe enough to mask the occupants of the vehicle.

Filters. Problems with glare were partially solved by using polarizing filters. The effect of these filters varied considerably, depending upon the angle of the sun in relationship to the passing cars. The polarizing filters had the undesirable effect of reducing the light-gathering capability of the cameras by one complete "f" stop.

The most undesirable filters encountered were the privacy screens, or tinted windows, installed in many new vehicles. These tinted screens keep both cameras and roadside observers from viewing the interior of vehicles.

Infrared Possibilities. HOV lane surveillance must take place when the majority of HOV lane users are in transit. This usually means the early morning and late evening hours. Since peak traffic periods can start before dawn and extend after dusk, ATD tested the use of infrared lamps to augment ambient light from bridge-top camera positions. The infrared lamps made it possible to record license plates after dark. No attempts were made to illuminate oncoming traffic using infrared lamps, however, since it was feared that the lamps might prove to be a distraction for drivers.

It also appears feasible to use infrared lighting in conjunction with a low-level camera to extend the hours of operation of the surveillance system after dark. This approach would focus infrared lamps and a near-infrared sensitive camera on the windows of the car after it had passed, so that the light source could be shielded from the view of the driver. These lamps will illuminate the interior of the car from the low-elevation camera positions. This should make high-speed recording possible under night-time conditions, although ATD did not undertake a low elevation test employing infrared lamps.

4.1.2 Camera Specifications

Contrast Ratio. The NTSC television signal is limited to a contrast ratio of approximately 10:1 That means that ten shades of gray can be resolved when looking at the TV screen. Unfortunately, the ratio between the bright unfiltered sunlight and the light in the interior of a moving vehicle may exceed 100:1. Very careful adjustment of the camera system must be made to compensate for these wide ranging light levels. For instance, it may be necessary to let the sky "wash-out" in order to pick up the interior **of** the vehicle. As previously mentioned, highlights from windows **or bright** work will further complicate the recording of high-contrast images.

Motion Blur. HOV lane traffic typically moves at speeds from 50 to 65 mph. When using close-up images, the "blur" at a standard 1/60th of a second exposure rate will be unacceptable. At these speeds, tests were made at 1/100th, 1/500th, 1/1000th and 1/2000th of a second. These tests showed that an exposure time of 1/1000th of a second are required. This exposure rate reduces the light availability by four "f" stops. In order to compensate for the light loss, a modified color NTSC camera should be used that has at least 24db of gain boost. It is preferable to have an automatic gain circuit as well as a manually selected gain capability.

Lens Selection. Since high speed exposures are required, very low-light-level cameras must be used. Field tests showed that it was desirable for the observer to have five-to-ten seconds to determine the number of occupants in the front seat of an oncoming vehicle. To accomplish this, a lens with a long focal length must be focused on oncoming vehicles that are approximately 1/4 mile away. Experimentation led to the selection of a 14:l zoom lens having a focal length from 20 mm to 280 mm.

Monochrome or Color Capability. Tests were run with both monochrome (black and white) and color cameras. Although the monochrome system seems to have slightly better contrast and resolution capability, the advantages of using color in identifying vehicles far outweigh the slight loss in resolution when a color system is used. However, careful technical alignment of the cameras is required to satisfy the stringent timing requirements needed to synchronize color cameras. Slight timing imperfections can cause significant changes in the perceived color of the same vehicle displayed in different quadrants of the same picture.

Resolution. In order to see sufficient detail in the interior of a moving vehicle, adequate resolution must be achieved by the camera, the recording medium, and the viewing monitors. A color system having the resolving capability of 300 tv lines is desirable. It is necessary to record multiple images within one frame of view. The recorded resolution is reduced by about 25% in each quarter/frame image. In order to resolve the license plate numbers, the field-of-view must be limited to no more than an eight foot segment of the traffic lane. This makes it possible to resolve five horizontal dots across each letter or number on the license plate.

4.1.3 Camera Positions

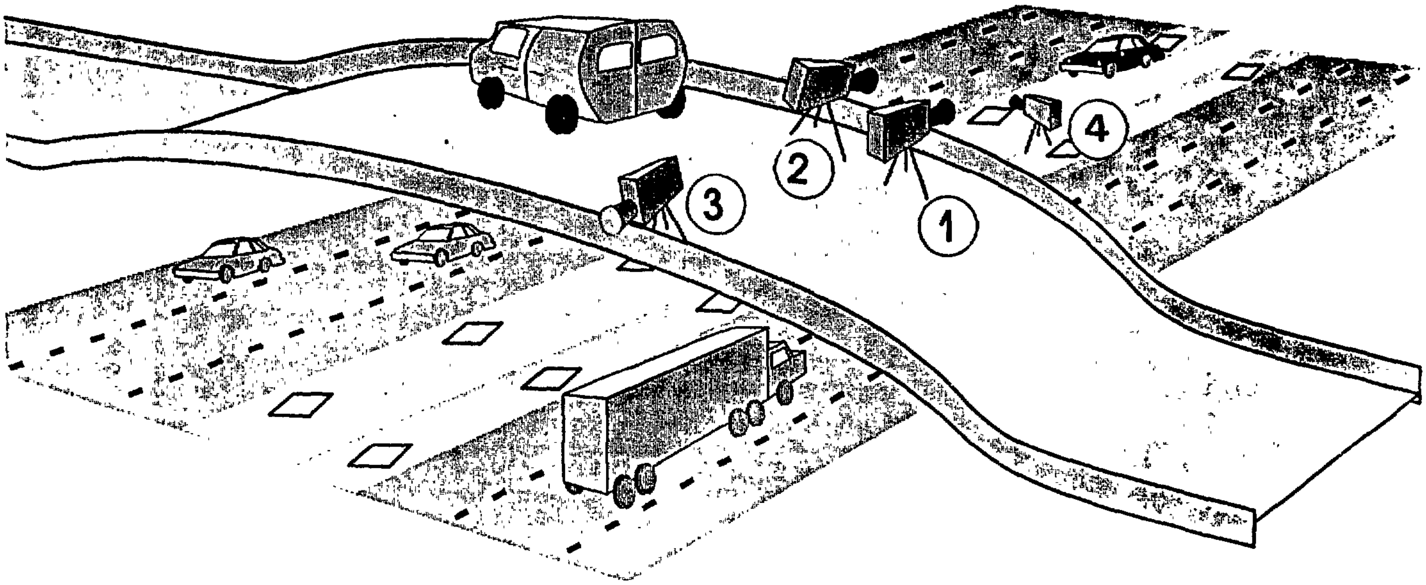
Many tests were conducted with cameras situated in different locations on top of overcrossings and at various locations in the median shoulder alongside HOV lanes. Four camera views appeared to provide the maximum amount of information about vehicle occupancy. These views are diagrammed in Exhibit 14.1.

Bridge Cameras. As shown in this exhibit, one camera is set up to observe oncoming traffic at approximately 1/4 mile from the overcrossing. The long range view provided by Camera #1 does not allow the observer to look down into the front seat to see a rider who is resting in a reclining seat, or a child who is below the level of the dashboard. To overcome this defect, a second camera is positioned to look down into the vehicle at a much steeper angle. This camera should be aimed so that the vehicle is picked up shortly after it disappears from the view of the first camera. If the views of cameras 1 and 2 are tightly synchronized, monitor observers have an easier time picking up the second image, and are more likely to rely on it in making on-line decisions.

EXHIBIT 4.1

SAMPLE CAMERA POSITIONS

1. Oncoming View
2. Oblique Oncoming View
3. License View
4. Eye-Level View



Eye-Level Camera. A third camera is set up in the median barrier approximately 100 feet from the overcrossing. It is located approximately five feet above the level of the road and is pointed at an angle approximately 30° from the perpendicular to the traffic. This camera provides a view of the rear seat occupants and a second check on the occupants of the seat next to the driver. Best results were obtained from the eye-level camera when it was positioned under the overpass itself. The shadow of the overpass minimized ambient light changes and maximized the contrast available in shots inside the vehicle.

License Camera. The fourth camera is set up to document license plate numbers. If the plates are being recorded primarily for subsequent off-line reviews, the license plate camera should be located on the overcrossing and aimed downward at a steep angle. This downward angle often provides additional information on the occupants of the rear seat.

If license plates are being recorded primarily as an aid for on-line enforcement, the license plate camera should be located approximately five feet above the roadway about 125 feet from the overcrossing. This license plate camera should be aimed to record the vehicle at the same time that the eye-level camera is documenting occupancies. In this way, both images will be on the screen at the same time, and the task of identifying the particular vehicle is simplified.

4.1.4 Cable Requirements

Recent introduction of some color high-speed video cameras that allow power to be transmitted down the video cable have simplified the set-up of HOV cameras. These units can be used up to 500 feet from the control van without the use of additional power cables. This allows the use of only one small (1/4" diameter) cable for each camera. In addition, cameras that are powered from one simple control are relatively easy to time correctly from the van location.

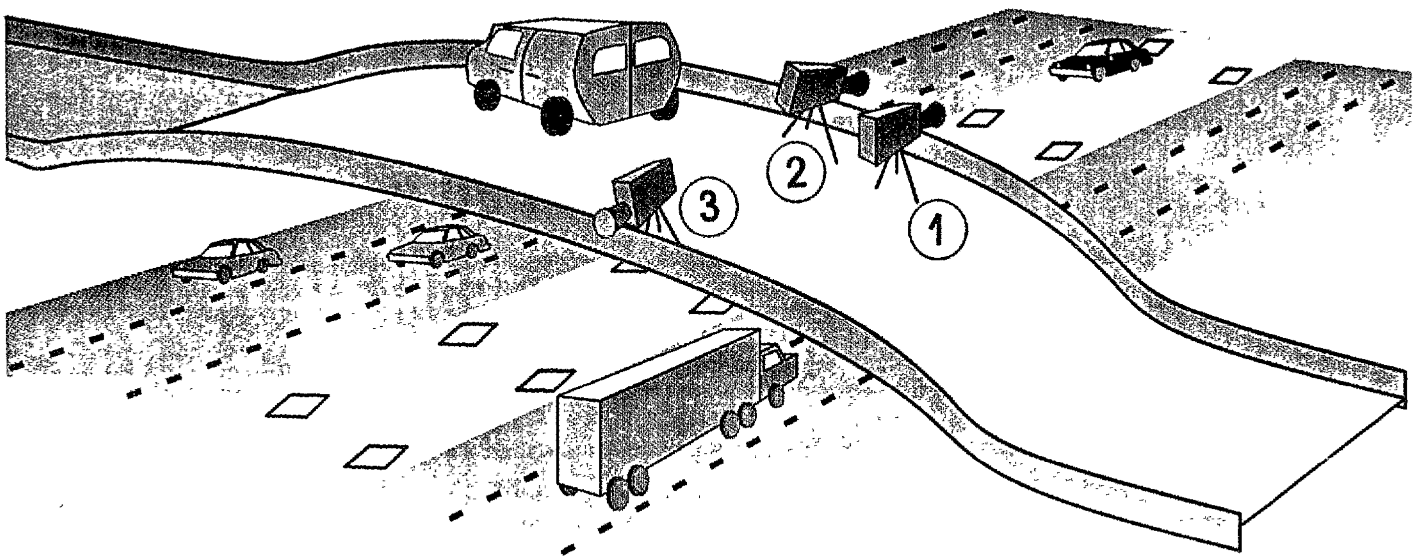
4.2 DISPLAY PREFERENCES

4.2.1 Real Time Decisions

For real-time decision-making, viewers seemed to prefer a monitor display showing three views of the suspect vehicles: (1) An oncoming view; (2) An oblique view downward into the passenger seat; and (3) A view of the license plate. Exhibit 4.2 shows a sample of these three

EXHIBIT 4.2

SAMPLE VIEWS FROM BRIDGE CAMERAS



views. The view from the oncoming camera is displayed vertically on a full half screen in order to provide as much time as possible for an initial judgment regarding the number of occupants in a particular vehicle. The remaining views are each displayed on a quarter of the monitor screen.

When making real-time decisions, viewers tended to pay more attention to the oblique view of the passenger seat, because it followed closely after the oncoming view and was somewhat easier to locate in a review mode. If the first two views showed a potential violator, the monitor viewer would ultimately stop the tape to document the license number of the vehicle.

When the eye-level camera was used, the view from that camera tended to be delayed until about seven seconds after the image of the vehicle had left the screen, so that the viewers were forced to wait and stop the tape to obtain a second view of suspect vehicles, then search for the license number. The need to search for the second view proved so bothersome in an on-line environment that some viewers ignored the second view and made decisions solely on the basis of the view from the initial camera.

4.2.2 Delaved Decisions

When decisions regarding vehicle occupancy could be delayed for more leisurely review away from the freeway, the most useful monitor display appeared to be one which provided the most information – that is, four views of the suspect vehicle. The four recommended views are the four views produced by the camera positions sketched in Exhibit 4.1: (1) An oncoming view of the vehicles; (2) A view of the license plate; (3) An oblique view downward into the passenger seat; and (4) An eye-level view through the side windows.

These four views were not tested simultaneously in an enforcement setting in the current study. However, such a test should be part of any future research program.

4.3 ACCURACY

4.3.1 Buffer Violations

Buffer violators, those drivers who enter or leave the HOV lane illegally by crossing the double yellow line where lane changing is not allowed, were easily identified by the camera recording oncoming traffic. Violator sightings were unambiguous, and the license plates of those drivers entering the lane are recorded by the video surveillance system.

4.3.2 Occupancy Violations

Videotape reviewers cannot currently identify the number of vehicle occupants with enough certainty to support citations for HOV lane occupancy violations. In early tests with three cameras located on an overpass, subsequent videotape review produced a false alarm rate of 21%. In later tests with one of the three cameras moved to the freeway itself, the false alarm rate rose to 51%. The chief cause of false alarms appeared to be small children and sleeping adults located out of the view of all three cameras.

Ambient lighting conditions, glare, and such vehicle design features as tinted windows, headrests, windshield posts, and high windows also made it difficult to interpret the number of videotaped vehicle occupants consistently. Videotape reviewers differed widely in their attempts to document vehicle occupancy levels. These differences suggest that tape reviewers must be well-trained to ensure that certain conditions (i.e., glare) do not trigger false alarms and that ambiguous views are treated consistently by all reviewers.

4.3.3 Roadside Occupancy Counts

It is difficult to draw general conclusions regarding the accuracy of roadside counters from the observations of two crews, since it is possible that the observations of different roadside observers will vary as greatly as those of different videotape reviewers. It appears, however, that roadside counters may overstate the number of HOV lane violators. One set of counters clearly understated the number of 3+ vehicles passing the observation point (this was the highest number of occupants required by their count sheets). Another set of counters apparently overstated the number of 6+ vehicles using count sheets with a heading for 6+ vans passing their observation point by assuming that most vans had six or more occupants.